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Online : WPI, INSPEC

(54) **Side impact airbag system with anticipatory sensor**

(57) This invention is a system to identify and monitor objects, such as vehicles, trees, motorcycles or walls, which could impact with a motor vehicle, such as an automobile or truck, by processing the signal received from the objects using one or more techniques, including neural networks or other pattern recognition systems, and technologies including ultrasonic and electromagnetic radiation. The received signal may be a reflection of a transmitted signal, the reflection of some natural signal from the object, or may be some signal emitted naturally by the object. Information obtained by the identification and monitoring system is then used to deploy an airbag usually prior to the impact of the object with the vehicle. In the case of side impacts, the anticipatory sensor permits the occupant to be moved away from the impact and the deployment of a large airbag to offer a level of protection heretofore not available. The occupant's seat and/or seatbelt may be arranged to provide easy movement of the occupant away from the impact region after inflation of the airbag. The airbag may be inflated at a first rate prior to collision and at a second rate upon detection of a collision. The use of external airbags with this system is also disclosed.

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This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

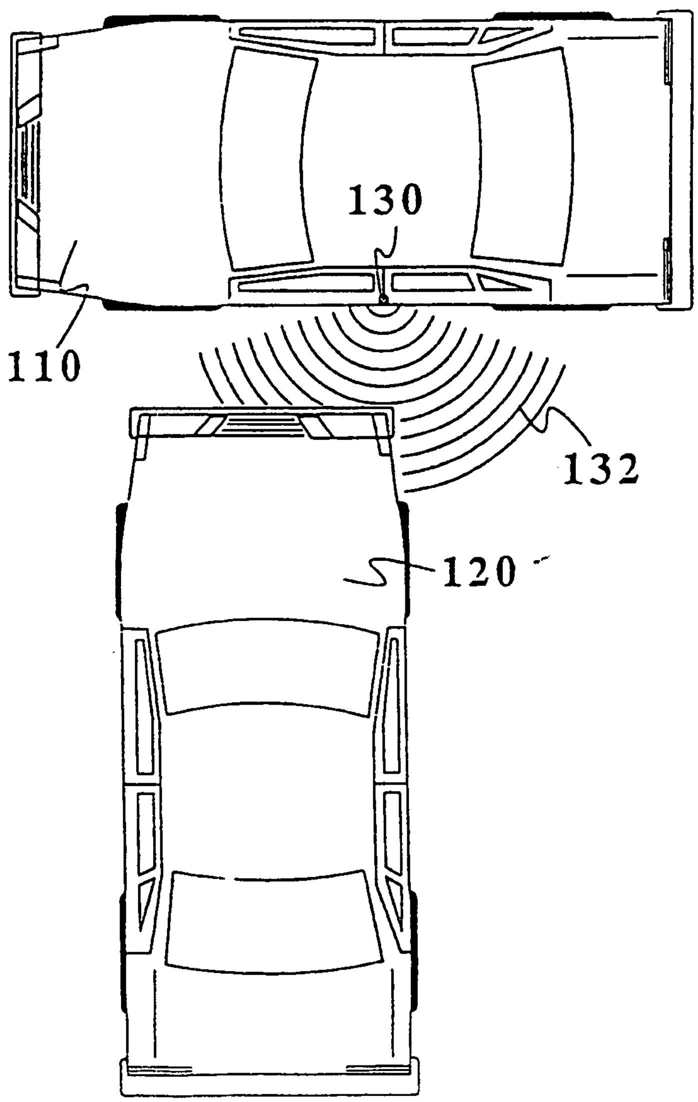

FIG. 1

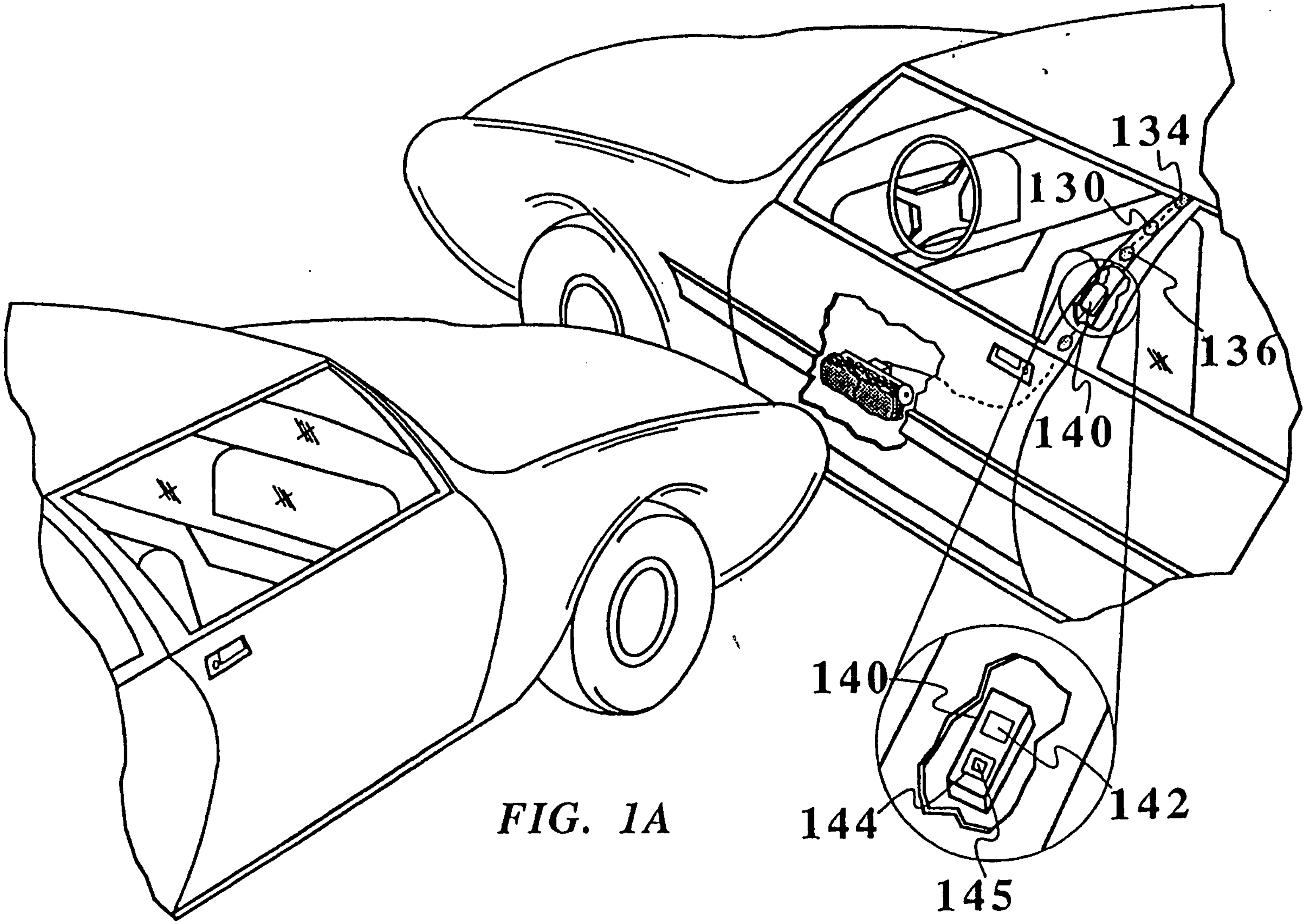

FIG. 1A

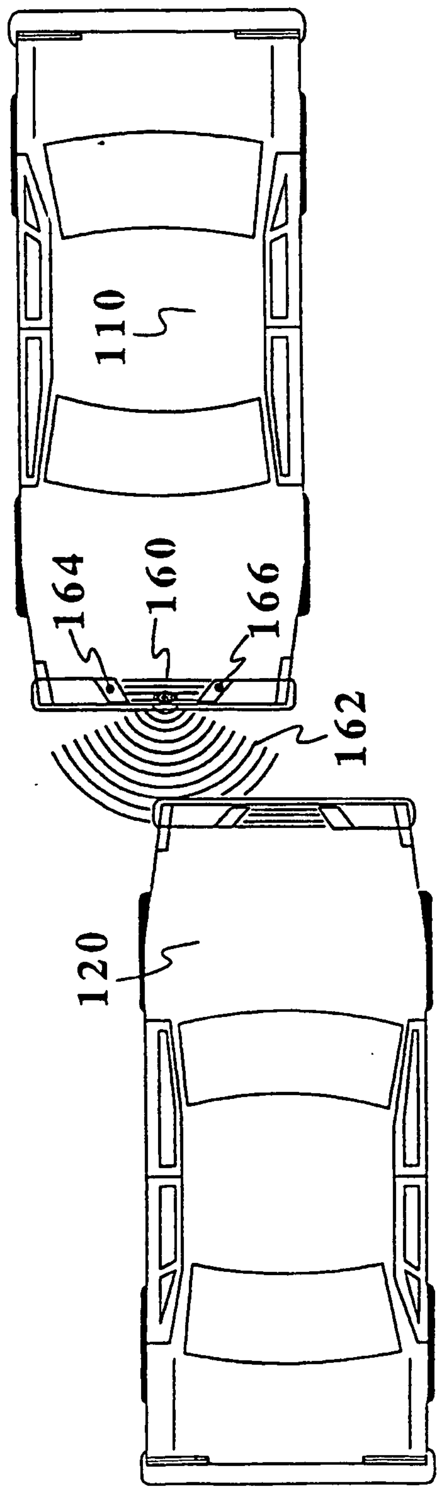

FIG. 2

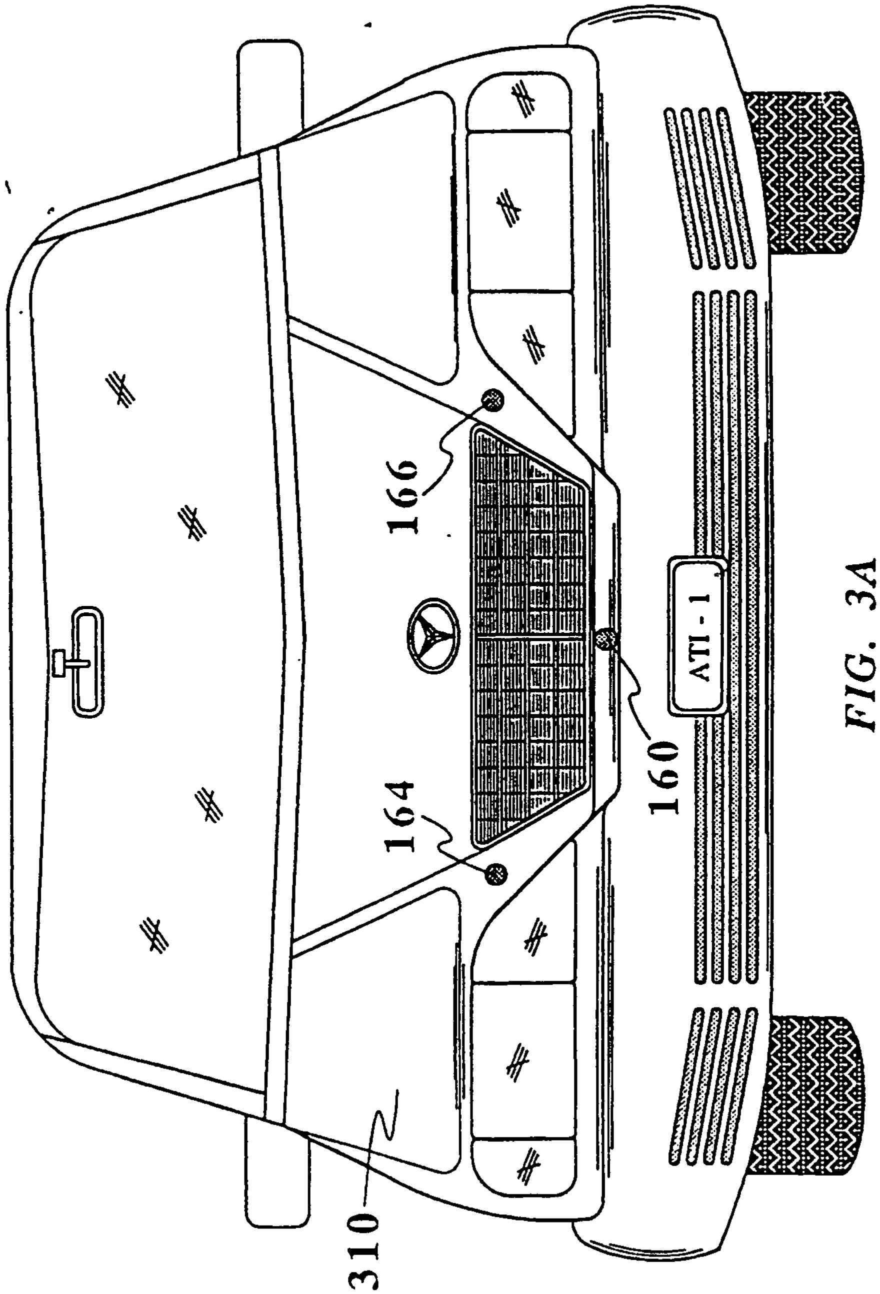

FIG. 3A

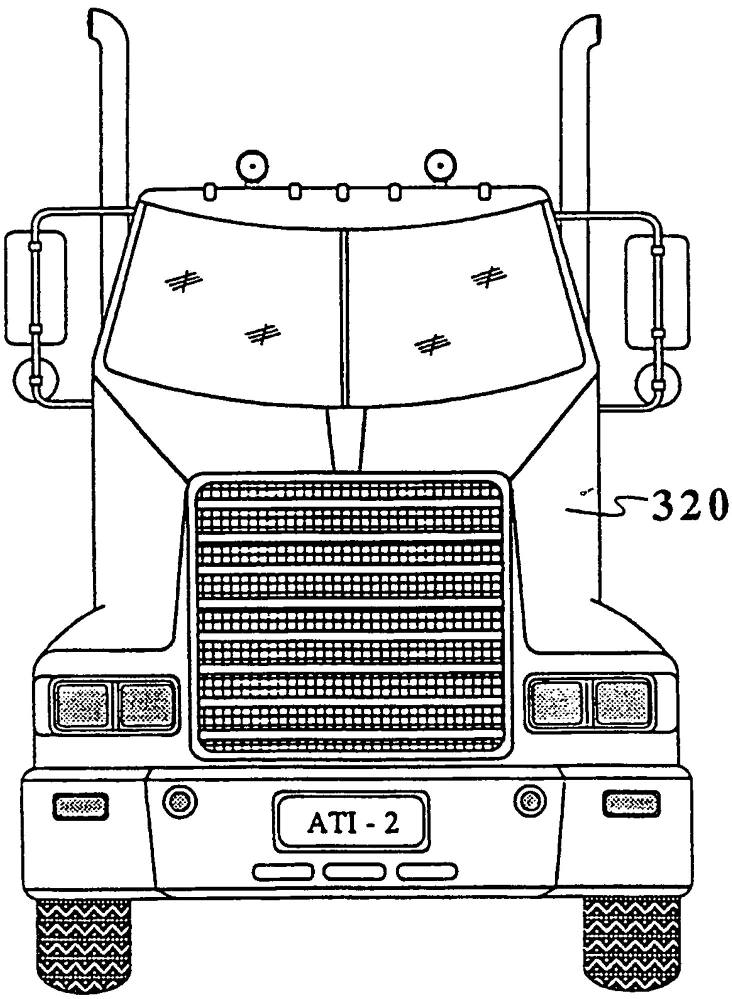

FIG. 3B

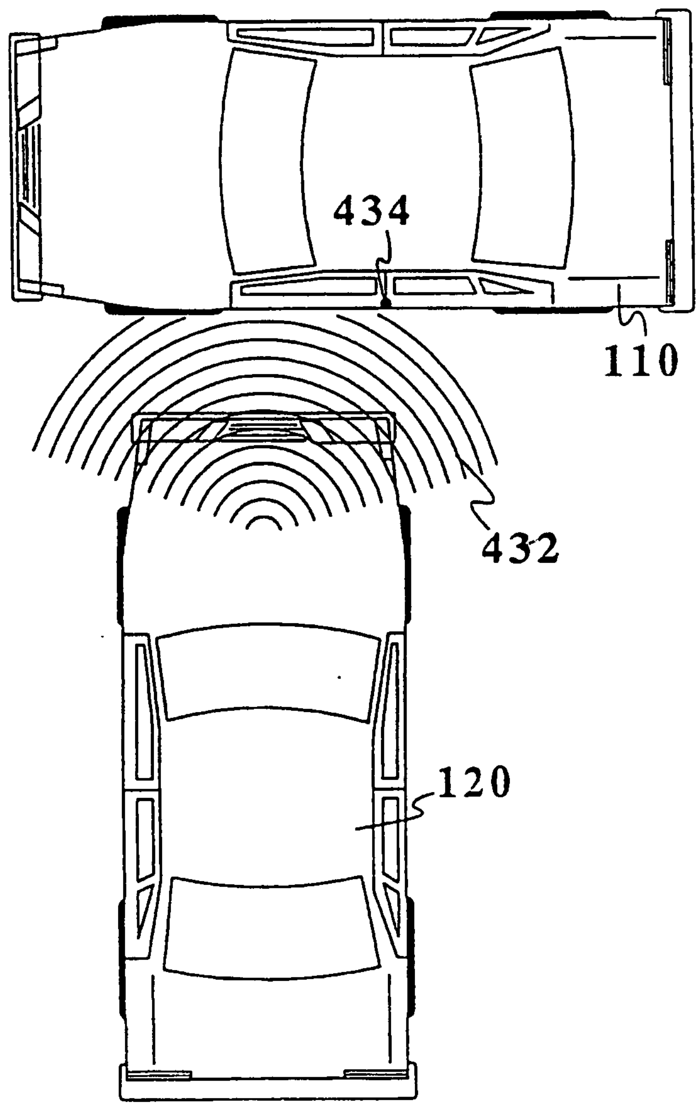

FIG. 4

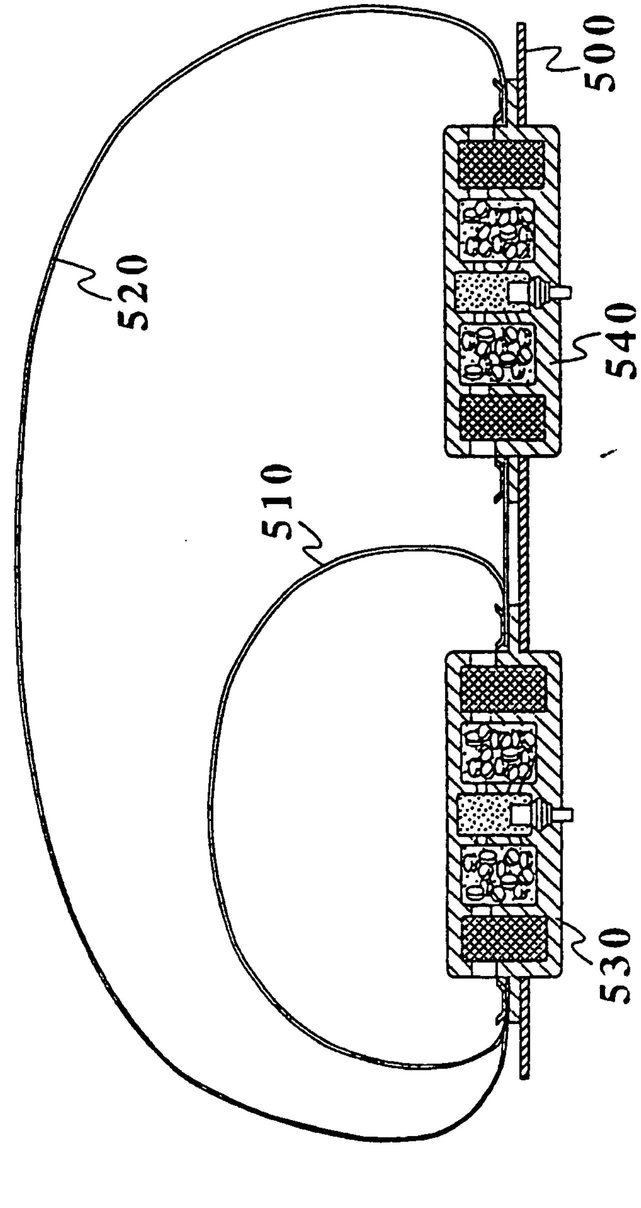

FIG. 5

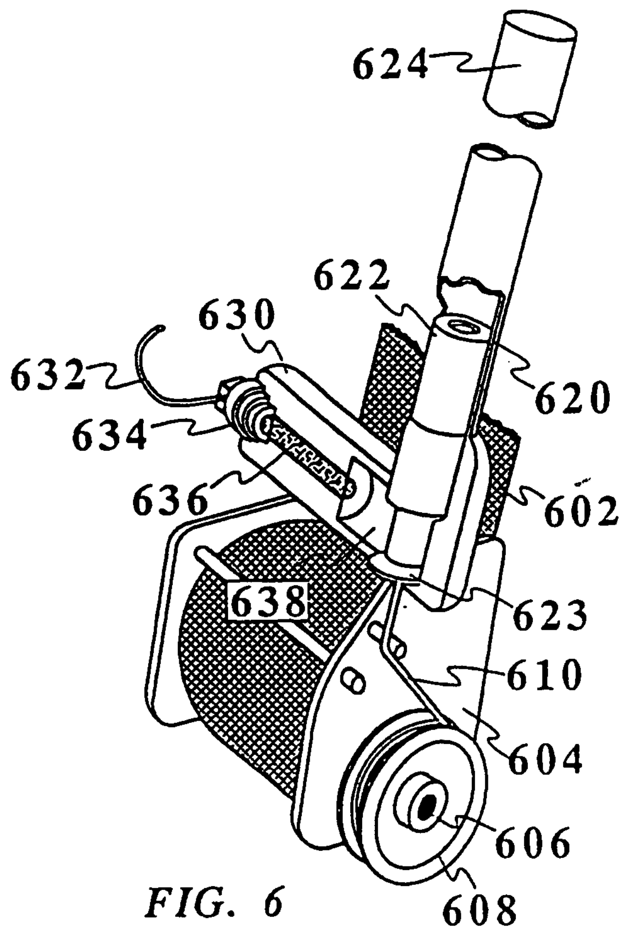

FIG. 6

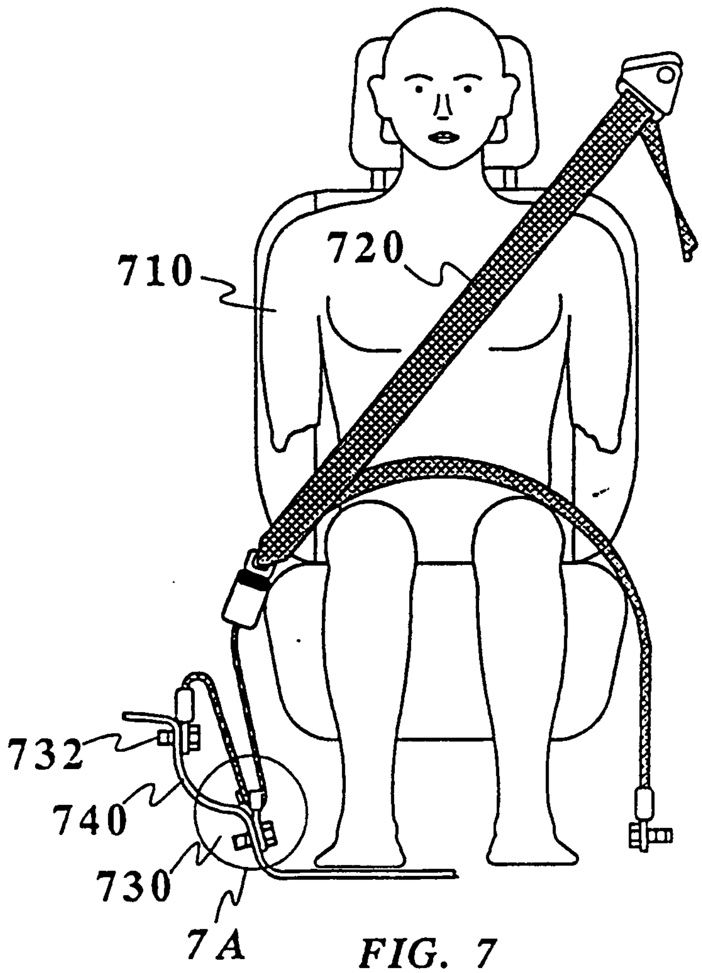

FIG. 7

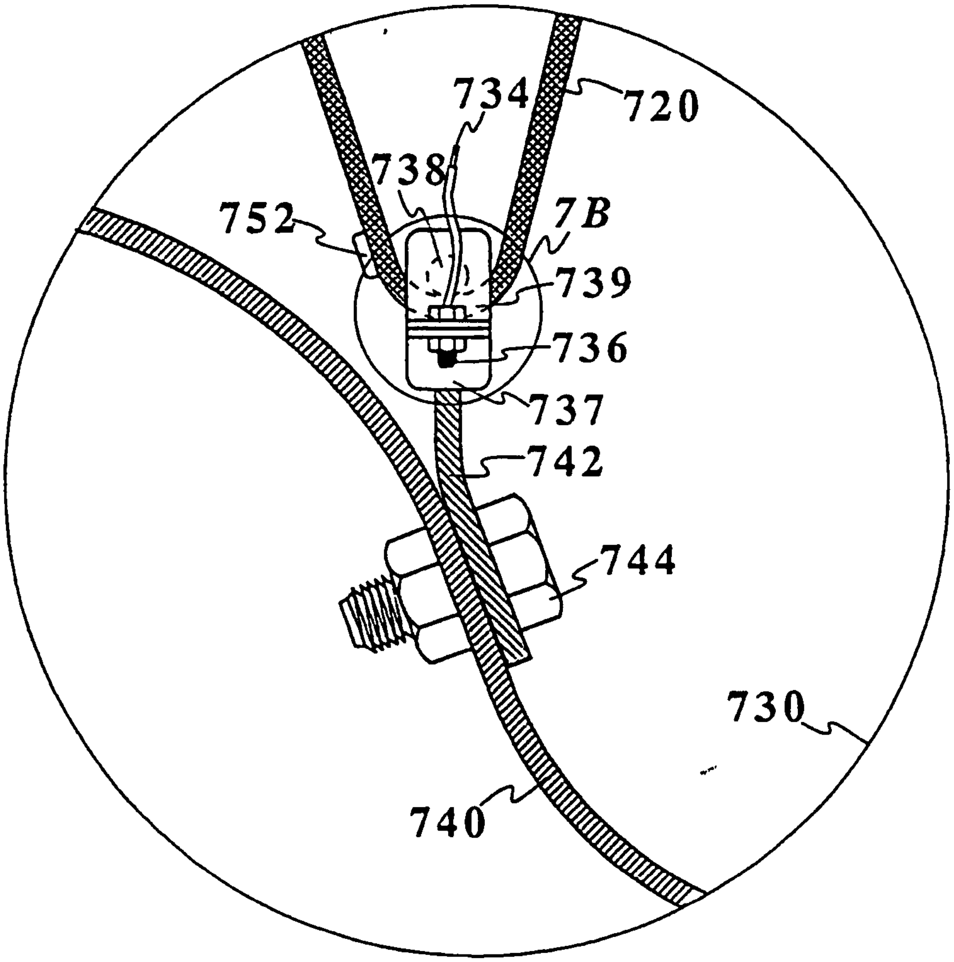
734
720
738
752
7B
739
736
737
742
744
730
740

FIG. 7A

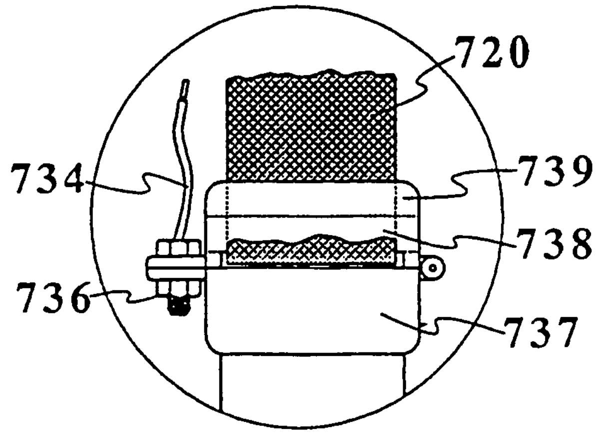
720
734
739
738
736
737

FIG. 7B

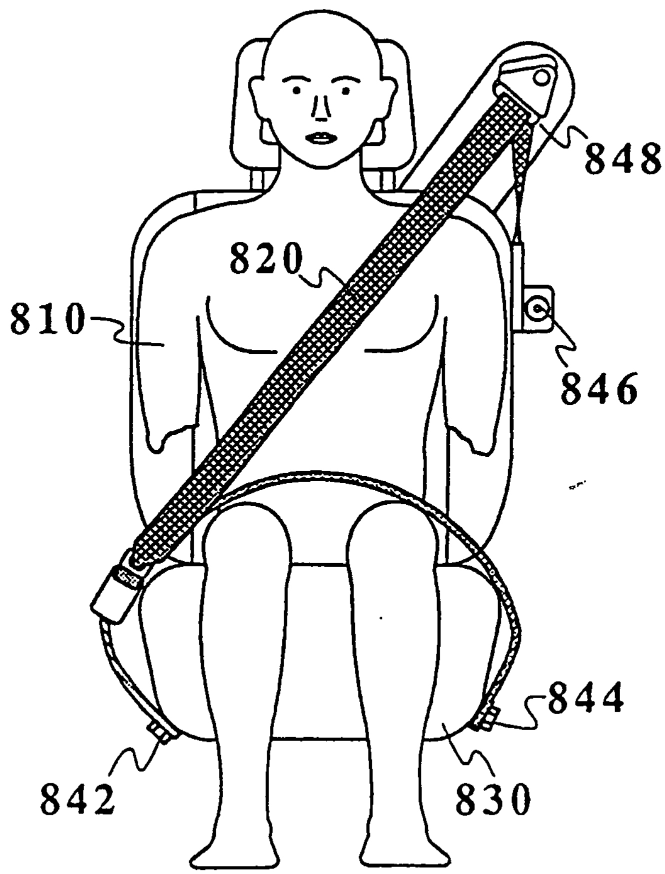

FIG. 8

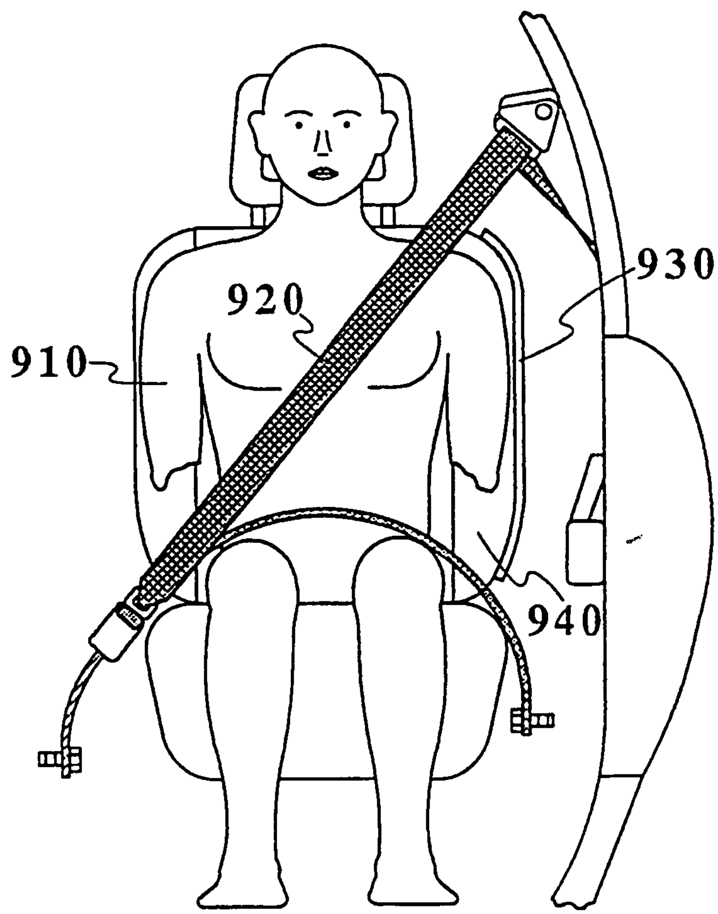

FIG. 9A

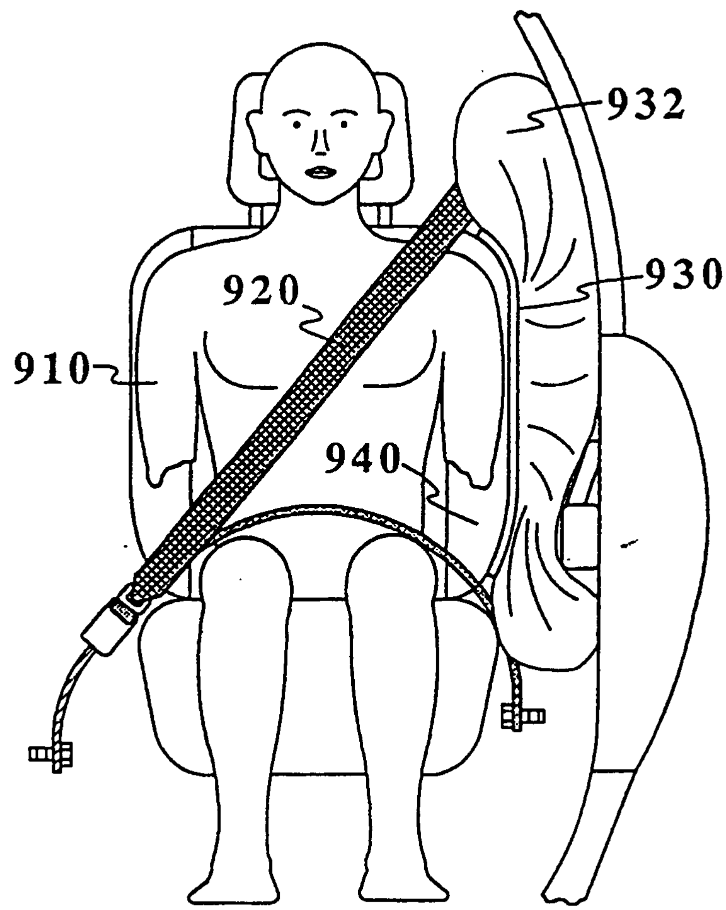

FIG. 9B

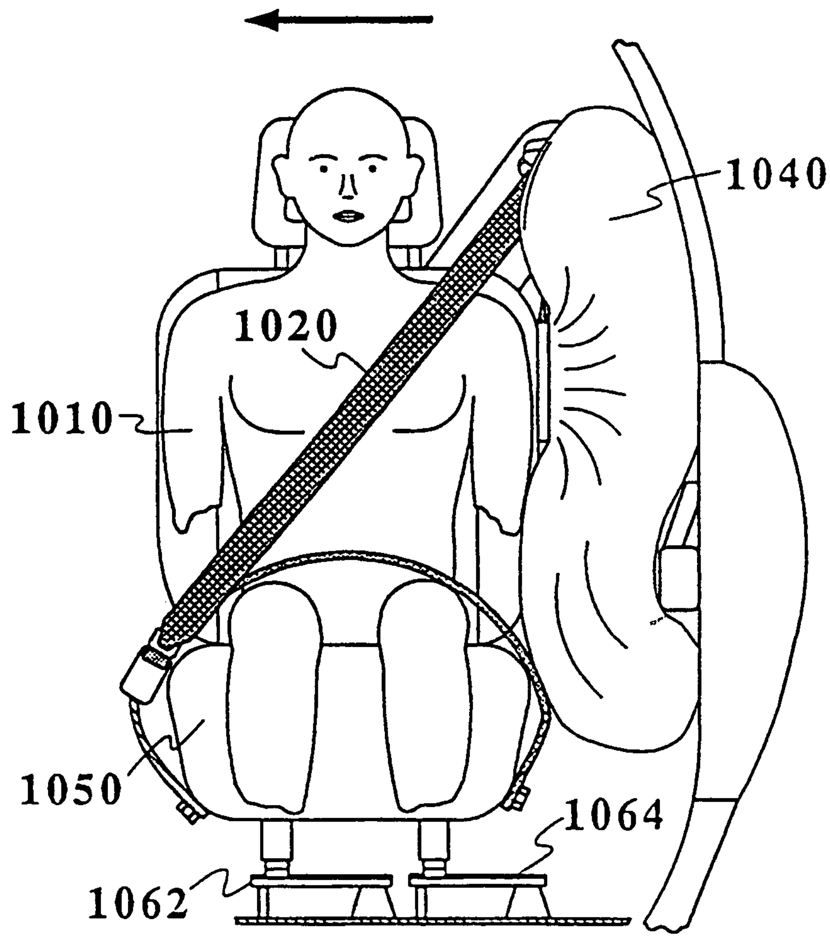

FIG. 10A

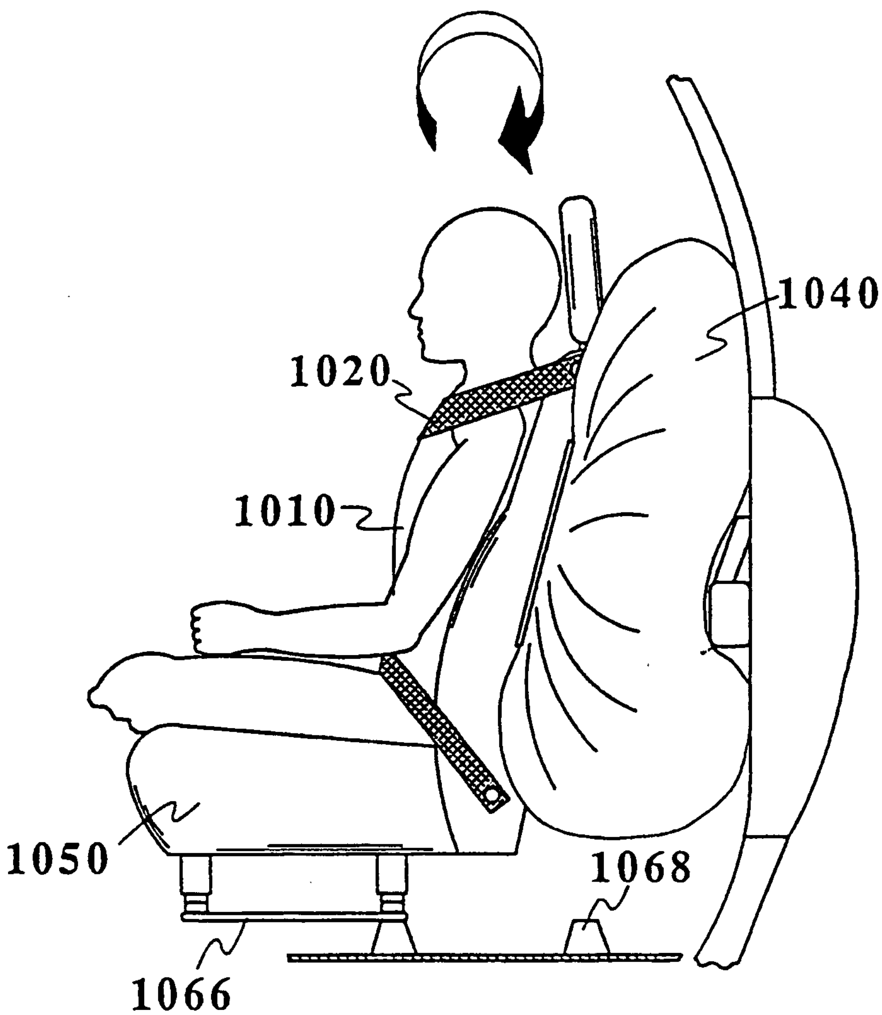

FIG. 10B

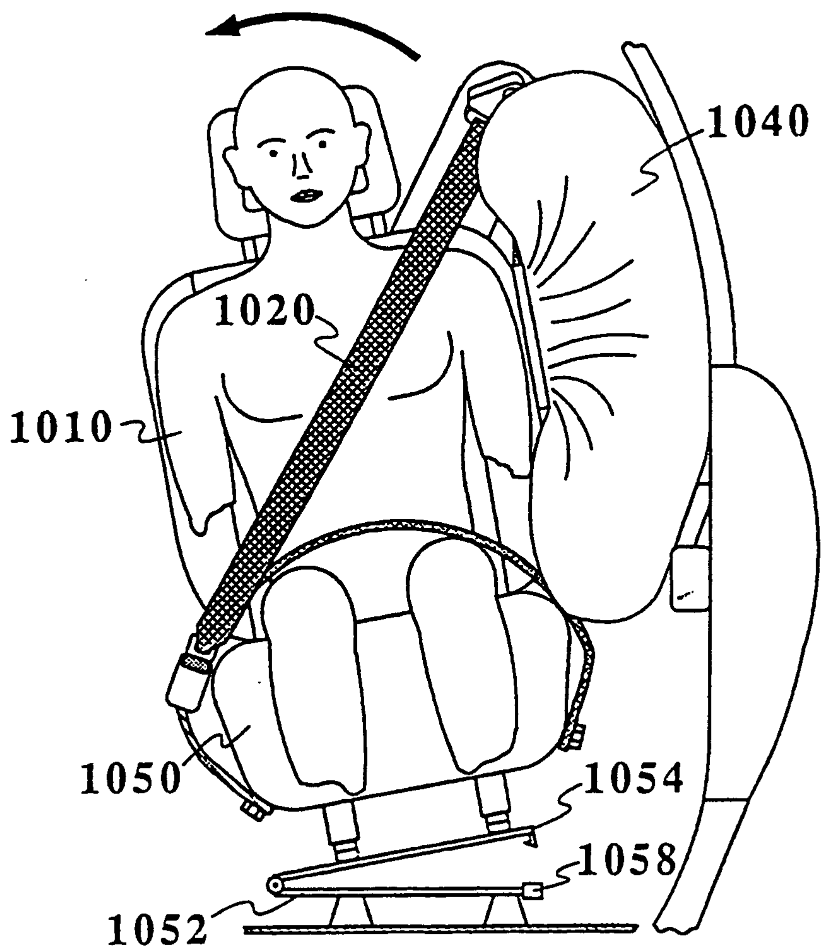

FIG. 10C

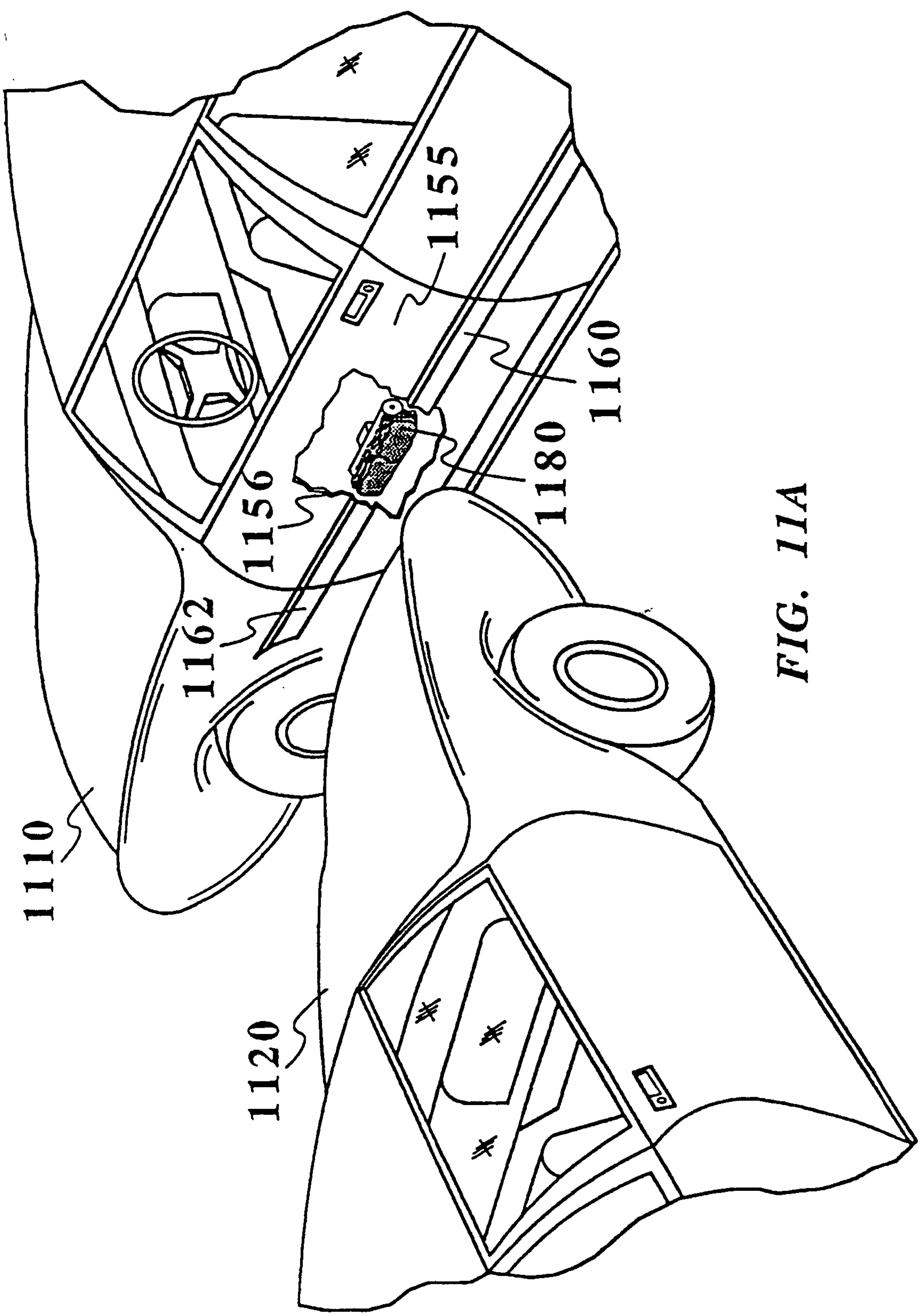

FIG. 11A

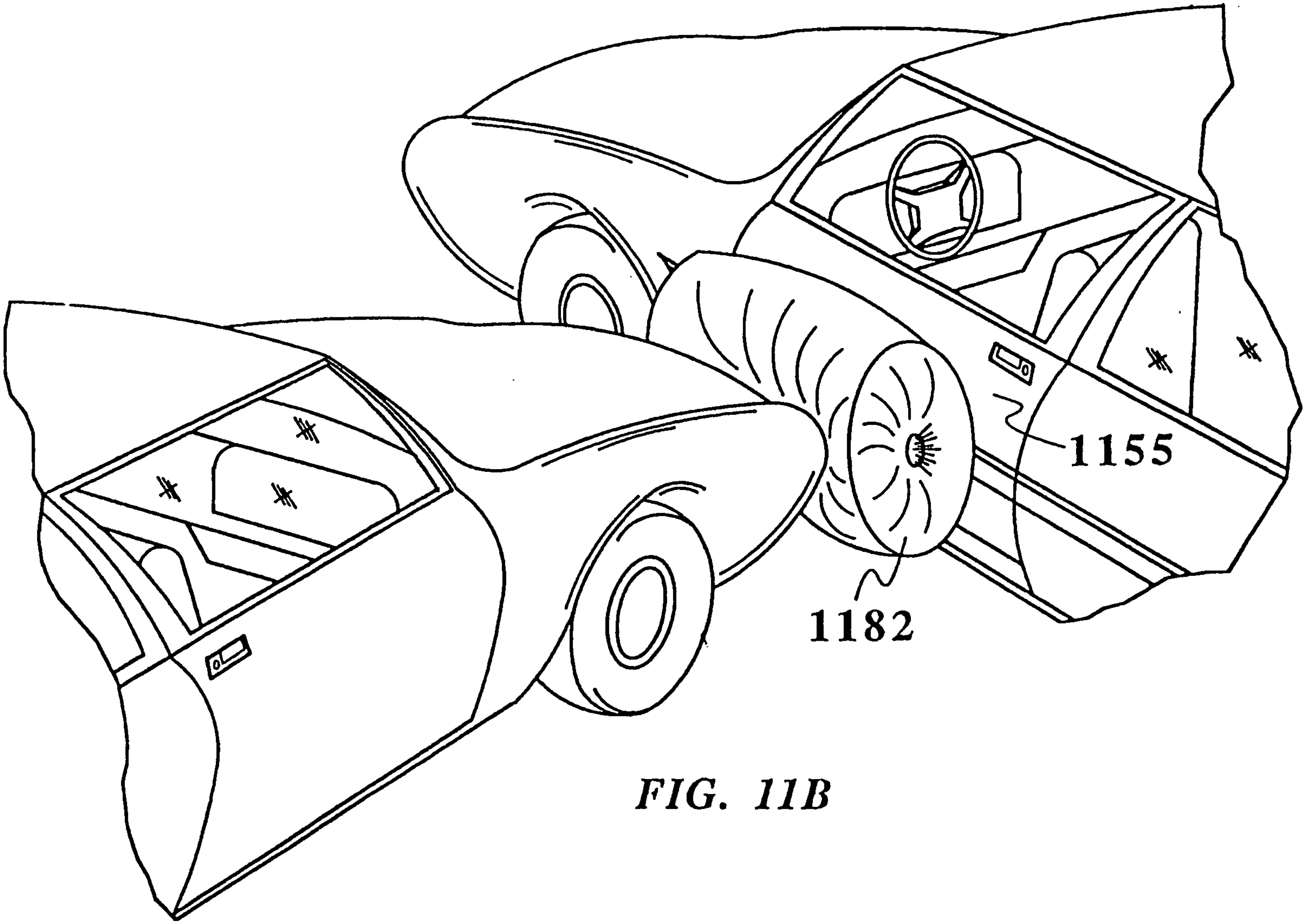

FIG. 11B

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SIDE IMPACT AIRBAG SYSTEM WITH ANTICIPATORY SENSOR

BACKGROUND OF THE INVENTION

Frontal impacts are the number one killer of vehicle occupants in automobile accidents with about 16,000 fatalities each year. Side impacts are the second cause of automobile related deaths with about 8,000 fatalities each year. The number of fatalities in frontal impacts is now decreasing due to the introduction of airbags and mandatory seatbelt use laws. It is natural now that a considerable effort be applied to saving lives in side impacts.

Several automobile manufacturers are now considering the use of side impact airbags to attempt to reduce the number of people killed or injured in side impacts. The side impact problem is considerably more difficult to solve in this way than the frontal impact problem due to the lack of space between the occupant and the side door and to the significant intrusion which typically accompanies a side impact.

Some understanding of the severity of the side impact problem can be obtained by a comparison with frontal impacts. In the Federal Motor Vehicle Safety Standard (FMVSS) 208 49 kph crash test which applies to frontal impacts, the driver, if unrestrained, will impact the steering wheel at about 30 kph. With an airbag and a typical energy absorbing steering column, there is about 40 to 50 cm of combined deflection of the airbag and steering column to absorb this 30 kph difference in relative velocity between the driver and vehicle interior. Also there is usually little intrusion into the passenger compartment to reduce this available space.

In the FMVSS 214 standard crash for side impacts, the occupant, whether restrained or not, is impacted by the intruding vehicle door also at about 30 kph. In this case there is

only about 10 to 15 cm of space available for an airbag to absorb the relative velocity between the occupant and the vehicle interior. In addition, the human body is more vulnerable to side impacts than frontal impacts and there is usually significant intrusion into the passenger compartment. A more detailed discussion of side impacts can be found in a paper by Breed et al, "Sensing Side Impacts", Society of Automotive Engineers No. 940651, 1994, which is included herein by reference.

Ideally an airbag for side impact protection would displace the occupant away from the intruding vehicle door in an accident and create the required space for a sufficiently large airbag. Sensors now being used for side impact airbags, however, begin sensing the crash at the beginning of the impact at which time there is insufficient time remaining to move the occupant before he is impacted by the intruding door. Even if the airbag were inflated instantaneously it is not possible to move the occupant to create the desired space without causing seriously injury. The problem is that the sensor which starts sensing the crash when the impact has begun, is already too late.

There has been discussion over the years in the safety community about the use of anticipatory sensors so that the side impact accident could be sensed before it occurs. Heretofore this has not been practical due to the inability to predict the severity of the accident prior to the impact. A heavy truck, for example, or a tree is a much more severe accident at low velocity than a light vehicle or motorcycle at high velocity. Until now it has not been possible to differentiate between these different accidents with a high degree of certainty.

Once a sufficiently large airbag is deployed in a side impact and the driver displaced away from the door and the steering wheel, he will no longer be able to control the vehicle which could in itself cause a serious accident. It is critically important, therefore, that such

an airbag not be deployed unless there is great certainty that the driver would otherwise be seriously injured or killed by the side impact. Anticipatory sensors have heretofore not been used because of their inability to predict the severity of the accident. The present invention solves this problem and therefore makes anticipatory sensing practical. This permits side impact airbag systems which can save a significant percentage of the people who would otherwise be killed as well as significantly reducing the number and severity of injuries. This is accomplished through the use of pattern recognition technologies such as neural networks such as discussed in co-pending patent application attorney docket number ATI-77 filed May 9th, 1994.

Neural Networks are capable of pattern recognition with a speed, accuracy and efficiency heretofore not possible. It is now possible, for example, to recognize that the front of a truck or another car is about to impact the side of a vehicle when it is one to three meters or more away. This totally changes the side impact strategy since there is now time to inflate a large airbag and push the occupant out of the way of the soon to be intruding vehicle. Naturally not all side impacts are of sufficient severity to warrant this action and therefore there will usually be a dual inflation system as described in more detail below.

Although the main application for anticipatory sensors is in side impacts, frontal impact anticipatory sensors can also be used to identify the impacting object before the crash occurs. Prior to going to a full frontal impact anticipatory sensor system, neural networks can be used to detect many frontal impacts using data in addition to the output of the normal crash sensing accelerometer. Simple radar or acoustic imaging, for example, can be added to current accelerometer based systems to give substantially more information about the crash and the impacting object than possible from the acceleration signal alone.

The side impact anticipatory sensor of this invention can use any of a variety of

technologies including optical, radar, acoustical, infrared or a combination of these. The sensor system typically contains a neural network processor to make the discrimination however a simulated neural network, a fuzzy logic or other algorithm operating on a microprocessor can also be used.

SUMMARY AND OBJECTS OF THE INVENTION

This invention comprises an anticipatory sensor system which uses (i) a source of radiant energy either originating from or reflected off of an object or vehicle which is about to impact the side of a target vehicle, plus (ii) pattern recognition means to analyze the radiant energy coming from the impacting object or vehicle to (iii) assess the probable severity of a pending accident and (iv) if appropriate, inflate an airbag prior to the impact so as to displace the occupant away from the path of the impacting object or vehicle to create space required to cushion the occupant from an impact with the vehicle interior. Although the primary area of application of this invention is for protection in side impacts, the invention also provides added protection in frontal impacts by reducing the incidence of injury to out-of-position occupants by permitting a slower inflation of the airbag and displacing the occupant away from the airbag prior to the impact.

The principal objects and advantages of this invention are:

1. To provide for the enhanced protection of occupants in side impacts by determining the probable severity of a pending accident and inflating an airbag prior to the impact to displace the occupant away from the vehicle door.
2. To provide for a method of identifying and classifying an object which is about to impact a vehicle.
3. To adapt pattern recognition techniques, and particularly neural networks, to permit

the identification of objects external to an automotive vehicle and the determination of their approach speed and angle of potential collision.

4. To provide a method for assessing the probable severity of a pending accident based on the identification of the class of an object which is about to impact the vehicle plus stored information about the class of such objects such as its mass, strength and attachment to the earth.

5. To provide a method using an ultrasonic system for use in illuminating an object which is about to impact a vehicle and using the reflection of the ultrasonic illumination in combination with a pattern recognition system to identify the object.

6. To determine the approach velocity of an object which is about to impact a vehicle.

7. To identify that a truck is about to impact a vehicle.

8. To identify that an automobile is about to impact a vehicle.

9. To identify that a vehicle is about to impact with a tree.

10. To provide a method using an electromagnetic wave system for use in illuminating an object which is about to impact a vehicle and using the reflection of the electromagnetic wave illumination in combination with a pattern recognition system to identify the object.

11. To provide a method using an the passive infrared electromagnetic waves radiating from an object such as a motor vehicle in combination with a pattern recognition system to identify the object.

12. To provide a system for identifying an object which is about to impact a vehicle in a substantially side impact.

13. To provide a system for identifying an object which is about to impact a vehicle in a substantially frontal impact.

14. To provide a system comprising a variable inflation airbag system where the control of the inflation of the airbag is determined by an prediction of the probable severity of an accident prior to the accident occurring.

15. To provide apparatus for inducing slack into a seatbelt in the event of a side impact to permit the occupant to be displaced sideways in the vehicle.

16. To provide for a single airbag module for protection of the head and torso of an occupant in side impacts.

17. To provide a single airbag module for mounting in the seat back of a vehicle for the protection of the head and torso of an occupant in side impacts.

18. To provide a structure and method for moving the occupant and his seat in the event of a side impact accident to increase the space between the occupant and the intruding object.

19. To provide for an airbag to be deployed external to the vehicle in conjunction with an anticipatory sensor in side impacts.

20. To provide a method using an ultrasonic wave system for use in illuminating an object which is about to impact a vehicle and using the reflection of the ultrasonic wave illumination in combination with a pattern recognition system to identify the object.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an overhead view of a vehicle about to be impacted in the side by an approaching vehicle showing a wave transmitter part of the anticipatory sensor system.

FIG. 1A is a perspective view of a vehicle about to impact the side of another vehicle showing the location of the various parts of the anticipatory sensor system of this invention.

FIG. 2 is an overhead view of a vehicle about to be impacted in the front by an

approaching vehicle showing a wave transmitter part of the anticipatory sensor system.

FIG. 3A a plane frontal view of the front of a car showing the headlights, radiator grill, bumper, fenders, windshield, roof and hood.

FIG. 3B a plane frontal view of the front of a truck showing the headlights, radiator grill, bumper, fenders, windshield, roof and hood.

FIG. 4 is an overhead view of a vehicle about to be impacted in the side by an approaching vehicle showing an infrared radiation emanating from the front of the striking vehicle and an infrared receiver part of the anticipatory sensor system.

FIG. 5 is a side plane view with portions cutaway and removed of a dual inflator airbag system with two airbags with one airbag lying inside the other.

FIG. 6 is a perspective view of a seatbelt mechanism illustrating a device to release a controlled amount of slack into seatbelt allowing an occupant to be displaced.

FIG. 7 is a frontal view of an occupant being restrained by a seatbelt having two anchorage points on the driver's right side where the one is released allowing the occupant to be laterally displaced during the crash.

FIG. 7A is an expanded view of the release mechanism within the circle 7A of FIG. 7.

FIG. 7B is a view of the apparatus of FIG 7A within the circle 7B and rotated 90 degrees showing the release mechanism.

FIG. 8 is a frontal view of an occupant being restrained by a seatbelt integral with seat so that when seat moves during a crash with the occupant, the belt also moves allowing the occupant to be laterally displaced during the crash.

FIG. 9A is a frontal view of an occupant being restrained by a seatbelt and a linear airbag module (930) attached to seat back to protect entire occupant from his pelvis to his head.

FIG. 9B is a view of the system of FIG. 9A showing the airbag in the inflated condition.

FIG. 10A is a frontal view of an occupant being restrained by a seatbelt and where the seat is displaced toward vehicle center by deploying airbag in conjunction with other apparatus.

FIG. 10B is a frontal view of an occupant being restrained by a seatbelt and where the seat is rotated about vertical axis in conjunction with other apparatus.

FIG. 10C is a frontal view of an occupant being restrained by a seatbelt and where the seat is rotated about longitudinal axis in conjunction with other apparatus.

FIG. 11A is a perspective view with portions cutaway and removed of a vehicle about to impact the side of another vehicle showing an airbag stored within the side door of the target vehicle prior to being released to cushion the impact of the two vehicles.

FIG. 11B is a view of the apparatus of FIG. 11A after the airbag has deployed.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 an overhead view of a vehicle 110 about to be impacted in the side by an approaching vehicle 120 where vehicle 110 is equipped with an anticipatory sensor system showing a transmitter 130 transmitting waves 132 toward vehicle 120. A perspective view of vehicle 110 is shown in FIG. 1A and illustrates the transmitter 130 connected to electronic module 140. Module 140 contains circuitry 142 to drive transmitter 130 and circuitry 144 to process the returned signals from receivers 134 and 136. Circuitry 144 contains a neural computer 145 which performs the pattern recognition determination based on signals from receivers 134 and 136.

Throughout the description herein, the term "approaching" when used as an object or

vehicle approaching another will mean the relative motion of the object toward the vehicle having the anticipatory sensor system. Thus, in a side impact with a tree, the tree will be considered as approaching the side of the vehicle and impacting the vehicle. In other words, the coordinate system used in general will be a coordinate system residing in the target vehicle. The "target" vehicle is the vehicle which is being impacted. This convention permits a general description to cover all of the cases such as where (i) a moving vehicle impacts into the side of a stationary vehicle, (ii) where both vehicles are moving when they impact, or (iii) where a vehicle is moving sideways into a stationary vehicle, tree or wall.

In a preferred implementation, transmitter 130 is an ultrasonic transmitter operating at a frequency of approximately 40 khz, although other frequencies could be used. Similarly, receivers 134 and 136 are ultrasonic transducers and receive the reflected ultrasonic waves from vehicle 120.

A detailed discussion of pattern recognition technology as applied to the monitoring and identification of occupants and objects within a vehicle is discussed in detail in Breed et al co-pending US Patent application attorney docket number ATI-77 filed May 9, 1994 and included herein by reference. Although the application herein is for the identification of objects exterior to the vehicle, many of the same technologies, principles and techniques are applicable.

An example of such a pattern recognition system using neural networks using sonar is discussed in two papers by Gorman, R,. P. and Sejnowski, T. J. " Analysis of Hidden Units in a Layered Network Trained to Classify Sonar Targets", *Neural Networks*, Vol.1. pp 75-89, 1988, and "Learned Classification of Sonar Targets Using a Massively Parallel Network", IEEE Transactions on Acoustics, Speech, and Signal Processing, Vol. 36, No. 7, July 1988.

"Pattern recognition" as used herein will mean any system which processes a signal

that is generated by an object, or is modified by interacting with an object, in order to determine which one of a set of classes that the object belongs to. Such a system might determine only that the object is or is not a member of one specified class, or it might attempt to assign the object to one of a larger set of specified classes, or find that it is not a member of any of the classes in the set. The signals processed are generally electrical signals coming from transducers which are sensitive to either acoustic or electromagnetic radiation and if electromagnetic they can be either visible light, infrared, ultraviolet or radar.

"To identify" as used herein will mean to determine that the object belongs to a particular set or class. The class may be one containing all trucks of a certain size or weight, one containing all trees, or all walls. In the case where a particular vehicle type is to be recognized, the set or class will contain only a single element, the particular vehicle type to be recognized.

Some examples follow:

In a passive infrared system, a detector receives infrared radiation from an object in its field of view, in this case the approaching object is most likely another vehicle, and processes the received infrared radiation radiating from the vehicle's engine compartment. The anticipatory sensor system then processes the received radiation pattern to determine the class of vehicle, and, along with velocity information from another source, makes an assessment of the probable severity of the pending accident and determines if deployment of an airbag is required. This technology can provide input data to a pattern recognition system but it has limitations related to temperature. The sensing of a non-vehicle object such as a tree, for example, poses a particular problem. The technology may also fail to detect a vehicle which has just been started especially if the ambient temperature is high.

Nevertheless, for use in the identification of approaching vehicles the technology can provide important information especially if it is used to confirm the results from another sensor system.

In a laser optical system an infrared laser beam 132 is used to momentarily illuminate an object as illustrated in FIG. 1 where transducer 132 is a laser transmitter. In some cases a charge coupled device (a type of TV camera) is used to receive the reflected light and would be used as one or both of the receivers 132 and 134. The laser can either be used in a scanning mode, or, through the use of a lens, a cone of light can be created which covers a large portion of the object. In each case a pattern recognition system, as defined above, is used to identify and classify the illuminated object and its constituent parts. This system provides the most information about the object and at a rapid data rate. Its main drawback is cost which is considerably above that of ultrasonic or passive infrared systems and the attenuation which results in bad weather conditions such as heavy rain, fog or snow storms. As the cost of lasers comes down in the future, this system will become more competitive. The attenuation problem is not as severe as might be expected since the primary distance of concern for anticipatory sensors as described here is usually less than three meters.

Radar systems have similar properties to the laser system discussed above with the advantage that there is less attenuation in bad weather. The wave length of a particular radar system can limit the ability of the pattern recognition system to detect object features smaller than a certain size. This can have an effect in the ability of the system to identify different objects and particularly to differentiate between different truck and automobile models.

The ultrasonic system is the least expensive and potentially provides less information than the laser or radar systems due to the delays resulting from the speed of sound and due

to the wave length which is considerably longer than the laser systems. The wave length limits the detail which can be seen by the system. In spite of these limitations, as shown in the above referenced Breed et al patent application attorney docket ATI-77, ultrasonics can provide sufficient timely information to permit the position and velocity of an approaching object to be accurately known and, when used with an appropriate pattern recognition system, it is capable of positively determining the class of the approaching object. One such pattern recognition system uses neural networks and is similar to that described in the papers by Gorman et al and in the rear facing child seat recognition system referenced and described in the Breed et al patent application referenced above.

A focusing system, such as used on some camera systems, could be used to determine the position of an approaching vehicle when it is at a significant distance away but is too slow to monitor this position just prior to a crash. This is a result of the mechanical motions required to operate the lens focusing system. By itself it cannot determine the class of the approaching object but when used with a charge coupled device plus infrared illumination for night vision, and an appropriate pattern recognition system, this becomes possible.

From the above discussion, it can be seen that the addition of sophisticated pattern recognition means to any of the standard illumination and/or reception technologies for use in a motor vehicle permits the development of an anticipatory sensor system which can identify and classify an object prior to the actual impact with the vehicle.

The application of anticipatory sensors to frontal impact protection systems is shown in FIG. 2 which is an overhead view of a vehicle 110 about to be impacted in the front by an approaching vehicle 120. In a similar manner as in FIG. 1, a transmitter 160 transmits waves 162 toward vehicle 120. These waves are reflected off of vehicle 120 and received by receiving transducers 164 and 166.

FIG. 3A illustrates the front of an automobile 310 and shows preferred locations for transmitting transducer 160 and receiving transducers 164 and 166. FIG. 3A also illustrates the distinctive features of the vehicle which cause a distinct pattern of reflected waves which will differ from that of a truck 320, for example, as shown in FIG. 3B. In some pattern recognition technologies, the researcher must determine the distinctive features of each object to be recognized and form rules which permit the system to recognize one object from another of a different class. An alternative method is to use artificial neural network technology wherein the identification system is trained to recognize different classes of objects. In this case a training session is conducted where the network is presented with a variety of objects and told to which class each object belongs. The network then learns from the training session and, providing a sufficient number and diversity of training examples are available, the network is able to categorize other objects which have some differences from those making up the training set of objects. The system is quite robust in that it can still recognize objects as belonging to a particular class even when there are significant differences between the object to be recognized and the objects on which the system was trained.

Once a neural network has been sufficiently trained, it is possible to analyze the network and determine the "rules" which the network evolved. These rules can then sometimes be simplified or generalized and programmed as a fuzzy logic algorithm. Alternately, a neural computer can be programmed and the system implemented on a semiconductor chip as available from Motorola.

The anticipatory sensor system must also be able to determine the distance, approach velocity and trajectory of the impacting object in addition to the class of objects to which it belongs. This is easily done with acoustic systems since the time required for the acoustic

waves to travel to the object and back determined its distance based on the speed of sound. With radar and laser systems, the waves usually need to be modulated and the phase change of the modulation determined in order to determine the distance to the object as discussed in more detail in US co-pending patent application 08/040,978 filed 3/31/93 to Breed et al and included herein by reference. Since the same distance measurement techniques are used here as in the two above referenced patent applications, they will not be repeated here.

There is a radar chip on the market which permits the distance determination based on the time required for the radar waves to travel to the object and back. This technology was developed by Amerigon Inc. of Burbank California and is being considered for other automotive applications such as constant distance cruise control systems and backing-up warning systems.

FIG. 3A is a plane frontal view of the front of a car showing the headlights, radiator grill, bumper, fenders, windshield, roof and hood and other objects which reflect a particular pattern of waves whether acoustic or electromagnetic. Similarly, FIG. 3B is a plane frontal view of the front of a truck showing the headlights, radiator grill, bumper, fenders, windshield, roof and hood illustrating a significantly different pattern. Neural network pattern recognition techniques using software available from NeuralWare Corp. of Pittsburgh, Pennsylvania can be used to positively classify trucks as a different class of objects from automobiles and further to classify different types of trucks giving the ability to predict accident severity based on truck type and therefore likely mass, as well as velocity. Other software tools are also commercially available for creating neural networks and fuzzy logic systems capable of recognizing patterns of this type.

In FIG. 4 an overhead view of a vehicle 110 about to be impacted in the side by an approaching vehicle 120 is illustrated where infrared radiation 432 is radiating from the

front of the striking vehicle 120. An infrared receiver 434 receives this radiation for processing as described above.

The anticipatory sensor system described and illustrated herein is mainly used when the pending accident will cause death or serious injury to the occupant. Since the driver will no longer be able to steer or apply the brakes to the vehicle after deployment of an airbag which is sufficiently large to protect him in serious accidents, it is important that this large airbag not be deployed in less serious accidents where the driver's injuries are not severe. Nevertheless, it is still desirable in many cases to provide some airbag protection to the driver. This can be accomplished as shown in FIG. 5 which is a side plane view with portions cutaway and removed of a dual inflator airbag system, shown generally as 500, with two airbags 510 and 520 with one airbag 510 lying inside the other airbag 520. Although a single inflator having a variable inflation rate capability can be used, FIG. 5 illustrates the system using two discrete inflators 530 and 540. Inflator 540 and associated airbag 520 are controlled by the anticipatory sensor and the inflator 530 and associated airbag 510 could also be initiated by the same system. In a less severe accident, inflator 530 can be initiated also by the anticipatory sensor without initiating inflator 540 or, alternately, inflator 530 could be initiated by another sensor system such as described US Patent 5,231,253 to Breed et al.

When the large airbag 520 is inflated from the driver's door, for example, it will attempt to displace the occupant away from the vehicle door. If the seatbelt attachment points do not also move, the occupant will be prevented from moving by the seatbelt and some method is required to introduce slack into the seatbelt or otherwise permit him to move. Such a system is shown in FIG. 6 which is a perspective view of a seatbelt mechanism where a device releases a controlled amount of slack into seatbelt allowing an occupant to be

displaced. The seatbelt spool mechanism incorporating the slack inducer is shown generally as 600 in FIG. 6 and includes the seatbelt 602, a housing for the spool mechanism 604, the spool 606 containing several layers of seatbelt material 602. Also attached to the spool 606 is a sheave 608 upon which is wound a cable 610. Cable 610 is connected to piston 622 of actuator 620. Piston 622 is positioned within cylinder 624 and is able to move within cylinder 624 as described below.

When the anticipatory sensor system decides to deploy the airbag, it also sends a signal to the seatbelt slack inducer system of FIG. 6. This signal is in the form of an electric current which passes through wire 632 and is of sufficient magnitude to ignite squib 634. Squib 634 in turn ignites propellant 636. Propellant 636 burns and produces gas which pressurizes chamber 638, which is in fluid communication with the bottom 623 of cylinder 624, and pressurizes cylinder 624 below piston 622. When subjected to this pressure, piston 622 is propelled upward within cylinder 624, pulling cable 610 and causing sheave 608 to rotate in the counterclockwise direction as shown in FIG. 6. This rotation causes the spool 606 to also rotate causing the belt to spool off of spool 606 and thereby inducing a controlled amount of slack into the belt and thus permitting the occupant to be displaced to the side.

In some cases, it may not be necessary to control the amount of slack introduced into the seatbelt and a simpler mechanism which releases the seatbelt can be used. An alternate system is shown in FIG. 7 which is a frontal view of an occupant 710 being restrained by a seatbelt 720 having two anchorage points 730 and 732 on the right side of the driver where the one 730 holding the belt at a point closest to the occupant 710 is released allowing the occupant 710 to be laterally displaced to the left in the figure during the crash. A detail of the release mechanism 730 taken within the circle 7A is shown in FIG. 7A. The mechanism

shown generally as 730 comprises an attachment bolt 744 for attaching the mechanism to the vehicle tunnel sheet-metal 740. Metal bracket 744 is attached to member 737. Member 737 is in turn attached to member 739 by means of explosive bolt assembly 736. Member 739 retains the seatbelt 720 by virtue of pin 738. A stop 752 placed on belt 720 prevents the belt from passing through the space between pin 738 and member 739 in the event that primary anchor 732 fails. Upon sensing a side impact crash, a signal is sent through wire 734 which ignites explosive bolt 736 releasing member 737 from 739 and thereby inducing a controlled amount of slack into the seatbelt.

In some implementations, the vehicle seat is so designed that in a side impact it can be displaced or rotated so that both the seat and occupant are moved away from the door. In this case if the seatbelt is attached to the seat, there is no need in induce slack into the belt as shown in FIG. 8. FIG. 8 is a frontal view of an occupant 810 being restrained by a seatbelt 820 integral with seat 830 so that when seat 830 moves during a crash with the occupant 810, the seatbelt 820 and associated attachments 842, 844, 846 and 848 also move with the seat allowing the occupant 810 to be laterally displaced during the crash.

Various airbag systems have been proposed for protecting occupants in side impacts. Some of these systems are mounted within the vehicle seat and consist of a plurality of airbag modules when both the head and torso need to be protected. An illustration of the use of this module is shown in FIG. 9A which is a frontal view of an occupant 910 being restrained by a seatbelt 920 and a linear airbag module 930, of the type described in the aforementioned patent application This linear module is attached to the side of seat back 940 to protect entire occupant 910 from his pelvis to his head.

A view of the system of FIG. 9A showing the airbag 932 in the inflated condition is shown in FIG. 9B.

In FIG. 10A a frontal view of an occupant 1010 being restrained by a seatbelt 1020 and wherein the seat 1050 is displaced toward vehicle center by deploying airbag 1040 is shown. In this case the seatbelt 1020 is attached to the seat 1050 as described above. In this case rail mechanisms 1062 and 1064 permit the seat to be displaced away from the door under the force produced by the deploying airbag 1040.

In FIG. 10B a frontal view of an occupant 1010 being restrained by a seatbelt 1020 and wherein the seat 1050 is rotated toward vehicle center by deploying airbag 1040 is shown. In this case the seatbelt 1020 is attached to the seat 1050 as described above. In this case rail mechanisms 1066 and mounting locations1068 permit the seat to be rotated away from the door under the force produced by the deploying airbag 1040. This figure is shown with the occupant rotated 90 degrees from initial position, this amount of rotation may be difficult for all vehicles. However, some degree of rotation about the vertical axis is possible in most vehicles.

In an alternate case where there is sufficient space for the occupants legs and feet, the seat 1050 can be rotated as shown in FIG. 10C. The rotating mechanism comprises a hinged assembly of two plates 1052 and 1054, with plate 1052 attached to the vehicle floorpan and plate 1054 attached to the vehicle seat 1050. The two plates are held together by a suitable clamp 1058 which is released by the sensor at the same time the airbag is deployed.

Once an anticipatory sensor system is in place, it becomes possible to consider deployment of an airbag external to the vehicle. This possibility has appeared in the automobile safety literature in the past but it has not been practical until the impacting object can be identified and an assessment of the probable severity of the accident made. For prior art systems, it has not been possible to differentiate between a construction barrier or a

cardboard box, for example, neither of which would not result in a serious accident and a concrete pillar, tree or wall which would. With the development of the pattern recognition systems described herein, and in the above referenced patent applications, this problem has been solved and the use of an external airbag now becomes feasible.

Such a system adapted for side impact protection is shown in FIG. 11A which is a perspective view with portions cutaway and removed of a vehicle 1110 about to be impacted in the side by another vehicle 1120. An airbag module is shown generally as 1180 mounted to the side door of the vehicle 1110 prior to inflation. A portion of the side door of vehicle 1110 has been cutaway to permit viewing of the airbag module 1180. The vehicle 1110 contains a strong support beam 1160 which provides a reaction surface along with the vehicle door 1155 for the airbag. Upon initiation by the anticipatory sensor, a deployment door, not shown, is opened in the external door panel 1156 by any of a number of methods such as pyrotechnically, permitting the airbag 1182 to emerge from the vehicle door 1155 as shown in FIG. 11B. Through a system such as illustrated in FIG.s 11A and 11B, the accident can be substantially cushioned prior to engagement between the vehicle and the impacting object. By this technique, an even greater protection can be afforded the occupant especially if an internal airbag is also used. This has the further advantage that the occupant may not have to be displaced from behind the steering wheel and thus the risk to causing an accident is greatly reduced.

Although several preferred embodiments are illustrated and described above, there are possible combinations using other geometries, sensors, materials and different dimensions for the components that perform the same functions. This invention is not limited to the above embodiments and should be determined by the following claims.

CLAIMS

1. In a motor vehicle having a side door, an airbag passive restraint system for protecting an occupant adjacent said door in a side impact comprising:

(a) an airbag, located between said side door and said occupant, said airbag when inflating providing sufficient force on said adjacent occupant to displace said occupant away from said side door:

(b) an side impact anticipatory sensor employing pattern recognition means for determining that an accident requiring deployment of said airbag is about to occur: and

(c) an inflator, responsive to said anticipatory sensor's determination that an airbag is required, to inflate said airbag:

wherein said anticipatory sensor, upon determining that an accident requiring deployment of the airbag is about to occur, causes said inflator to inflate said airbag prior to said impact.

2. The invention in accordance with claim 1 wherein said pattern recognition means comprises a neural network.

3. The invention in accordance with claim 1 wherein said pattern recognition means comprises a fuzzy logic algorithm.

4. The invention in accordance with claim 1 wherein said pattern recognition means comprises a rule based algorithm.

5. The invention in accordance with claim 1 wherein said anticipatory sensor comprises electromagnetic waves.

6. The invention in accordance with claim 1 wherein said anticipatory sensor comprises acoustic waves.

7. In a motor vehicle, a system for triggering deployment of an airbag passive restraint system in anticipation of a collision between said motor vehicle and an object of a certain class, said object approaching said motor vehicle, said system comprising:

(a) transmitter means for sending waves from said motor vehicle toward said object:

(b) receiver means for receiving reflected waves from said object and producing a signal representative of said waves:

(c) pattern recognition means connected to said receiver for (i) identifying the class of said object and (ii) determining whether said object will impact said vehicle resulting in an accident with sufficient severity to require deployment of said airbag:

(d) an airbag passive restraint system: and

(e) triggering means responsive to said pattern recognition means to initiate deployment of said airbag when required as determined by said pattern recognition means, wherein said anticipatory sensor, upon determining that an accident requiring deployment of the airbag is about to occur, causes said inflator to inflate said airbag prior to said impact.

8. The invention in accordance with claim 7 wherein said waves means comprises electromagnetic waves.

9. The invention in accordance with claim 8 wherein said electromagnetic waves comprise radar waves.

10. The invention in accordance with claim 7 wherein said waves means comprises ultrasonic waves.

11. The invention in accordance with claim 7 wherein said pattern recognition means comprises a neural network.

12. The invention in accordance with claim 7 wherein said collision is a

side impact.

13. The invention in accordance with claim 7 wherein said collision is a frontal impact.

14. The invention in accordance with claim 8 wherein said electromagnetic waves comprise light waves.

15. The invention in accordance with claim 8 wherein said waves means comprises infrared waves.

16. The invention in accordance with claim 7 wherein said receiver means comprises a charge coupled device.

17. In a motor vehicle having an passive restraint system with at least one airbag, a variable inflation rate inflator system for inflating said at least one airbag comprising:

(a) an anticipatory sensor for determining that a crash requiring an airbag will occur and, upon the making of such a determination, triggering said inflator to inflate said airbag at a first inflation rate;

(b) a second crash sensor for determining that a crash requiring an airbag is occurring and, upon the making of such a determination and if said inflator has not already been triggered, triggering said inflator to inflate s airbag at a second inflation rate;

(c) an airbag

18. In a motor vehicle having a side door, an airbag passive restraint system for protecting an occupant adjacent said door in a side impact, said system located between said door and said occupant, said system comprising:

(a) an airbag, said airbag when inflating providing sufficient force on said adjacent occupant to displace said occupant away from said side door;

(b) a sensor for determining that deployment of said airbag is required;

(c) an inflator, responsive to said sensor's determination that an airbag is required, to inflate said airbag;

(d) a seatbelt for restraining said occupant, and

(e) means associated with said seatbelt for permitting said occupant to be displaced away from said side door upon inflation of said airbag.

19. In a motor vehicle having a side door and a seat, an airbag passive restraint system for protecting an adjacent occupant located in said seat in a side impact comprising:

(a) an airbag

(b) means to mount said airbag adjacent said occupant;

(c) anticipatory sensor means to initiate inflation of said airbag in the event of a side impact requiring deployment of said airbag, said inflation initiation occurring prior to the start of said impact;

(d) an inflator, responsive to said sensor's determination that an airbag is required, to inflate said airbag; and

(e) responsive means to said sensor operatively associated with said seat to increase the space between said occupant and said door upon inflation of said airbag.

20. In a motor vehicle having a side and an externally deployable airbag system for protecting an occupant in a side impact with an impacting object, said airbag system comprising:

(a) an external airbag deployable outside of said vehicle between said vehicle and said impacting object;

(b) an anticipatory sensor system for determining that a crash requiring an airbag will occur, and

(c) an inflator, responsive to said sensor's determination that an airbag is required, to inflate said external airbag prior to said impact.

22. In a motor vehicle having an exterior surface and an externally deployable airbag system for protecting an occupant in an impact, said airbag system comprising:

(a) an airbag deployable outside of said vehicle between said vehicle and said impacting object;

(b) an anticipatory sensor system for determining that a crash requiring an airbag will occur; and

(c) an inflator, responsive to said sensor's determination that an airbag is required, to inflate said external airbag prior to said impact.

Patents Act 1977 **Examiner's report to the Comptroller under Section 17** **(The Search report)**	Application number GB 9510408.9
Relevant Technical Fields (i) UK Cl (Ed.N) G4N-NHVSC (ii) Int Cl (Ed.6) B60R-21/00, 21/32	Search Examiner S J DAVIES Date of completion of Search 9 AUGUST 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE WPI, INSPEC	Documents considered relevant following a search in respect of Claims :- 1-6

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
A	GB 1333269	(TOYOTA) see eg page 1, lines 74-94; page 3, lines 53-78	
A	EP 0568017 A2	(TAKATA) see eg page 3, line 50 - page 4, line 7	

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